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In a later chapter the analysis of such measures, in combination, is discussed in detail.

II Variability of Commodity Prices

Commodities differ materially among themselves in respect to the amplitude and frequency of their price movements, their "proper fluctuations," in Edgeworth's phrase. The prices of certain commodities, such as bread, change but slightly or not at all over a long period of time. Others, of which potatoes are a notable example, are characterized by widely varying prices from month to month and from year to year. These differences in variability may be due to differences in the organic nature of the commodities in question, or to differences in the conditions under which they are produced, marketed and consumed.

The type of variability which is to be measured is a matter for determination before methods of measurement may be decided upon. For some purposes interest might attach to day-to-day, week-to-week, month-to-month or year-to-year variation, or to seasonal or cyclical price fluctuations. Cyclical movements are dealt with in section IV, below. No attempt has been made in this study to measure seasonal movements. It has not seemed feasible or desirable, for the purposes of the present inquiry, to compute measures of variability relating to such short intervals as the day or the week. These considerations restrict us in the present section to three indexes of price variability, one measuring the amplitude of monthly price fluctuations, another measuring the frequency of monthly price changes, a third measuring the amplitude of year-to-year movements.

1. The Measurement of Monthly Variability

In measuring the fluctuations of monthly prices within a given year, the mean deviation from the average price for the year has been employed. This measure may be exemplified with reference to the following price quotations.

TABLE 2

Average Monthly Prices of Print Cloths, at Wholesale, 1925
(27 inch, 64 x 60)

Month	Average price per yard	Month	Average price per yard
January	$.069	July	.065
February	.068	August	.066
March	.069	September	.067
April	.067	October	.067
May	.064	November	.063
June	.063	December	.061
		Average	.066

The average deviation of these twelve monthly prices from their mean is $.00208. Expressing this measure as a percentage of the mean, for purposes of comparison, we have a value of 3.2. Such measures have been computed for print cloths for the years from 1890 to 1926. These appear in Table 3 and, in graphic form, in Figure 1-C.

TABLE 3

MEASURES OF MONTHLY VARIABILITY OF PRINT CLOTH PRICES, 1890-1926

Year	Mean deviation as percentage of mean annual price	Year	Mean deviation as percentage of mean annual price
1890	2.6	1909	5.7
1891	1.6	1910	4.8
1892	7.2	1911	5.4
1893	12.5	1912	6.5
1894	2.7	1913	3.6
1895	7.5	1914	9.9
1896	3.5	1915	6.4
1897	3.5	1916	14.4
1898	4.0	1917	14.5
1899	4.3	1918	8.1
1900	5.9	1919	20.9
1901	7.4	1920	26.7
1902	4.4	1921	14.2
1903	2.2	1922	7.8
1904	10.9	1923	6.8
1905	13.0	1924	3.1
1906	4.4	1925	3.2
1907	7.4	1926	6.1
1908	6.8		

Measures of variability similar to the above have been computed for over two hundred commodities for each year from 1890 to 1926, employing wholesale price quotations. (The actual number varies from 204 to 214.) Each annual measure relates to price variation within the year, reflecting movements due to all causes, secular, seasonal, cyclical, or accidental. For some purposes it would be desirable to segregate these elements and to have measures of the price variation due to each of these forces acting in isolation. Partly because of the physical impossibility of analyzing in this refined fashion any large number of cases, no attempt has been made to separate these elements in measuring variability.[1] But there were other considerations in the choice of the present method. For many practical purposes the deviations of prices within a given year

[1]See, however, the measures relating to trends and to cyclical movements which are given in sections III and IV of this chapter.

from the average for that year need not be broken up and attributed to diverse forces. The price changes themselves are the facts of immediate concern to producers and consumers. A measure of these variations in the price of a single commodity may be accepted at its face value and compared with similar measures for other commodities.

If there is an appreciable upward or downward trend in the prices of a given commodity, or if these prices are subject to considerable changes from year to year for any reason, the absolute mean deviations for different years would not be comparable, since the bases from which the deviations are measured would differ materially in value. This difficulty is overcome by expressing the mean deviations as percentages of the respective annual averages. Thus, although the trend factor may slightly affect the value of the measure of variability for a given year, it does not lessen the comparability of measures for different years.

For most agricultural products more significance attaches to measures of price variability based upon monthly prices prevailing within the crop year than to measures derived from prices within the calendar year. The use of the calendar year introduces changing crop conditions as one important element in monthly variability. By restricting the annual measures to crop years we secure a time unit within which the influence of one crop is dominant. Such measures have been computed for 18 agricultural products, to which there correspond 19 price series.[1]

It is impossible to include in this report all the measures of

[1]Following are the commodities for which crop year measures have been computed. The crop years employed are indicated.

Commodity	Crop Year
Barley	August to July
Corn	November to October
Oats	August to July
Rye	July to June
Wheat	July to June
Beans	September to August
Cotton	August to July
Eggs	April to March
Flaxseed	September to August
Hay	July to June
Hops	July to June
Onions	July to June
Potatoes	September to May
Rice	August to July
Flour, rye	July to June
Flour, wheat	July to June
Apples (evaporated)	June to May
Cottonseed oil	August to July

FIGURE 1

VARIABILITY OF COMMODITY PRICES, AT WHOLESALE.

Measures of Monthly Variability, expressed as Percentages of Average Annual Prices, 1890-1926.

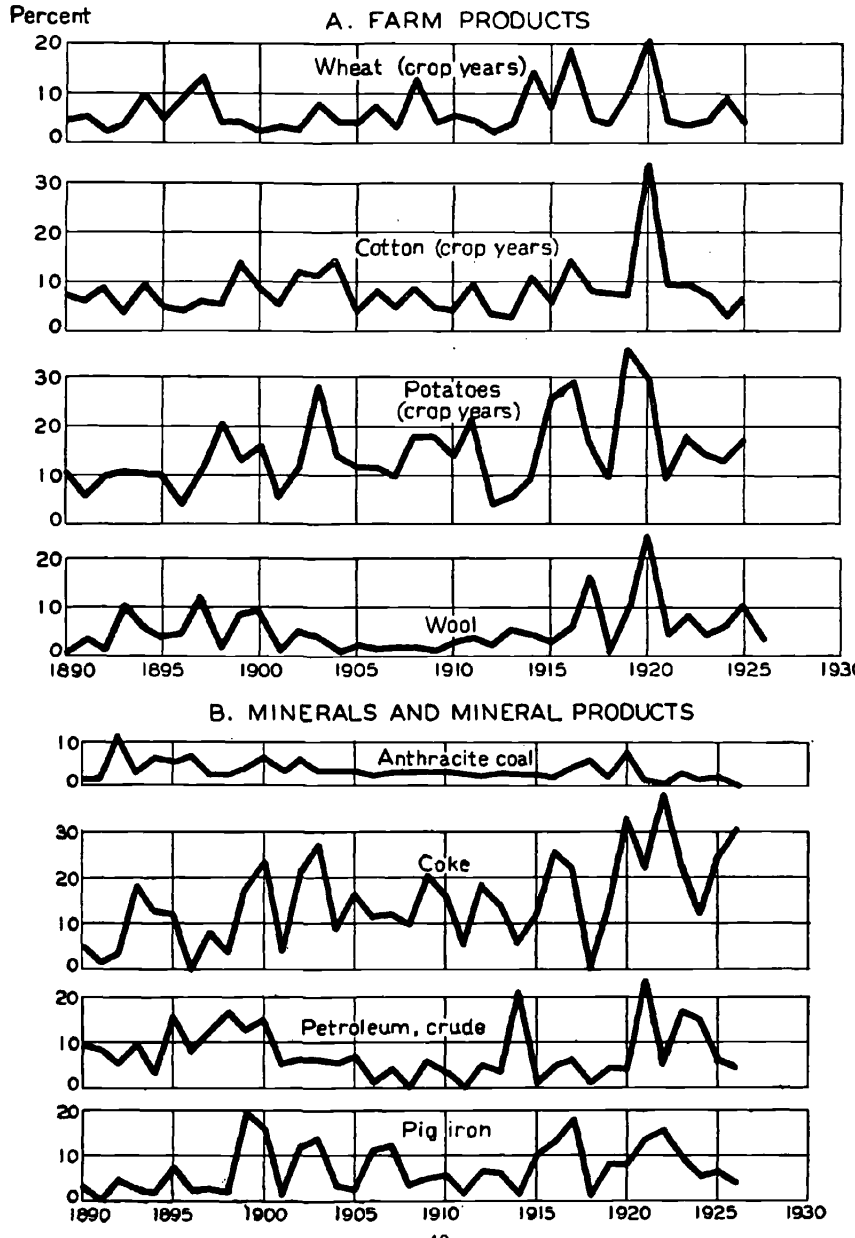


FIGURE 1 (Cont.)

VARIABILITY OF COMMODITY PRICES, AT WHOLESALE.

Measures of Monthly Variability, expressed as Percentages of Average Annual Prices, 1890-1926.

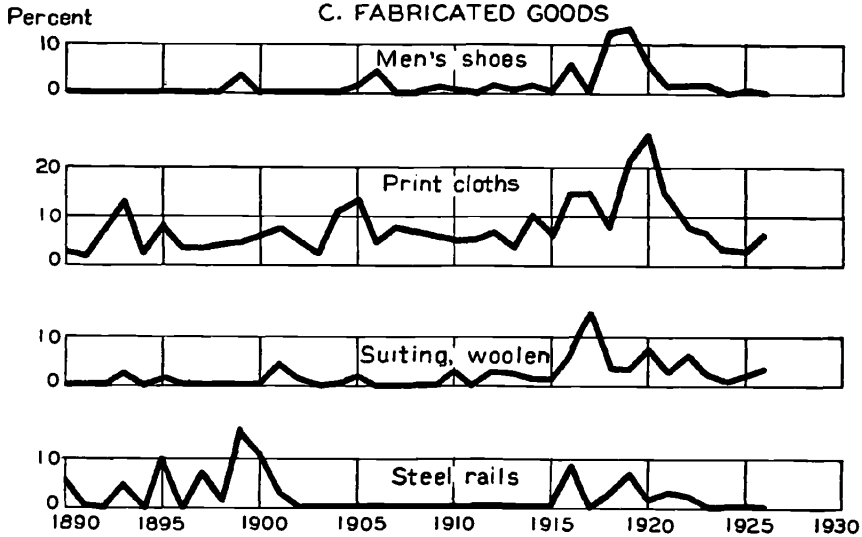
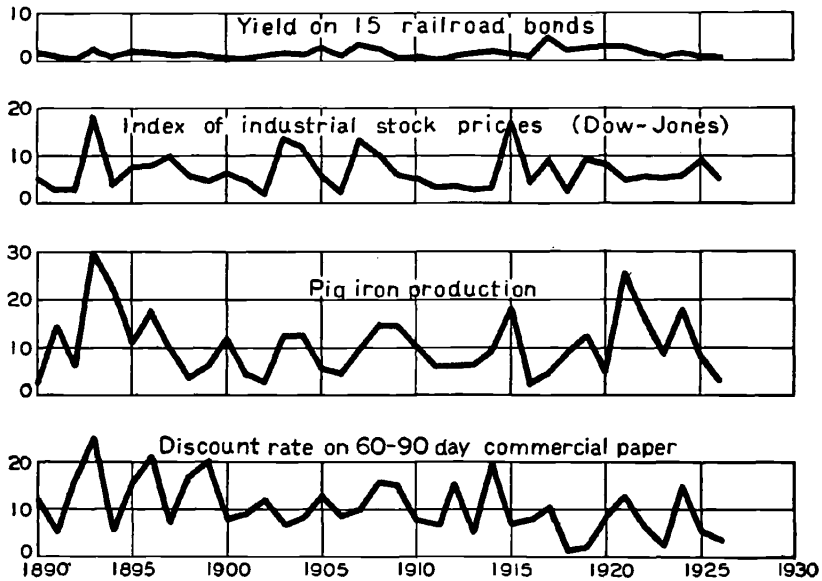


FIGURE 2

Measures of Monthly Variability of Four General Economic Series, expressed as Percentages of Average Annual Values 1890-1926.



variability computed for the separate years since 1890 for all the commodities studied. In Table II[1] annual measures for the years from 1890 to 1926 are given for three selected groups of commodities, representing agricultural products, raw minerals and metals, and fabricated industrial products. The measures for certain of these commodities are presented graphically in Figure 1. There are, it will be noted, pronounced differences between these commodities in respect to the magnitude of monthly price fluctuations and in the changes which have taken place in these movements during the period covered.

For comparison with these indexes of price variability corresponding measures have been computed for a number of other economic series. The annual values are given in Table III, of the Appendix. Four of these series are plotted in Figure 2.

The measures of monthly price variability for all commodities are shown, in summary form, in Tables IV and V. In order that changes in variability may be noted, the period from 1890 to 1925 has been divided into five subdivisions, including four periods of eight years each and a final period of four years, and a measure of variability has been computed for each of these periods. In addition, two general averages have been calculated. One of these is based upon the entire 36 years covered, the other upon the same data excluding the disturbed years, 1914 to 1921.[2]

The following figures, relating to the prices of nineteen important commodities, exemplify the results secured. These commodities are arranged in order of magnitude of the averages in column (9).

[1]Roman numerals refer to tables in the Appendix, while Arabic numbers refer to tables in the body of the text.

[2]The averages based upon crop-years cover only 35 years. The sub-periods are of the same length as those relating to calendar year measures, except for the second period, from 1898-99 to 1904-05, which includes but 7 years.

TABLE 4
MEASURES OF MONTHLY VARIABILITY OF PRICES OF SELECTED COMMODITIES, AT WHOLESALE, 1890-1925
Averages, by Periods

(1) Ref. No.[1]	(2) Commodity	(3) 1890–1897	(4) 1898–1905	(5) 1906–1913	(6) 1914–1921	(7) 1922–1925	(8) 1890–1925 inclusive	(9) 1890–1925 excluding 1914–21
280	Steel rails	3.4	3.9	0.0	3.1	.6	2.4	2.2
441	Leather	3.2	2.8	1.8	4.7	3.9	3.2	2.8
233	Anthracite coal	4.9	4.1	3.0	3.7	1.8	3.7	3.7
120	Flour, wheat[2]	4.5	3.4	4.8	9.9	5.2	5.7	4.4
293	Copper, ingot	5.3	3.7	6.1	8.3	4.1	5.7	4.9
64	Beef	5.4	4.2	5.4	5.8	4.9	5.2	5.0
236	Bituminous coal	5.7	5.4	2.1	9.4	9.2	6.0	5.0
202	Cotton yarns[3]	4.3	6.1	5.1	13.7	5.9	7.4	5.4
6	Wheat[2]	6.8	4.2	5.5	10.3	5.4	6.6	5.5
13	Cattle	4.9	4.3	6.0	7.0	8.4	5.9	5.6
195	Print cloths	5.1	6.5	5.6	14.4	5.2	7.6	5.7
259	Pig iron	3.1	8.6	6.5	9.3	11.9	7.1	6.5
149	Sugar, raw	8.5	5.1	6.8	12.4	9.2	8.3	7.1
276	Steel billets	6.6	9.8	5.9	9.6	5.4	7.7	7.2
25	Cotton[2]	6.5	10.1	5.7	11.3	7.3	8.2	7.3
247	Petroleum	9.0	9.4	2.9	8.1	10.5	7.7	7.6
451	Rubber	5.2	3.9	10.9	10.1	17.7	8.7	8.2
51	Potatoes[2]	9.0	15.5	13.6	20.0	13.5	14.4	12.7
239	Coke	7.7	15.3	13.3	16.8	24.4	14.5	13.9

[1]A reference number has been given to each wholesale price series used. A complete list, with descriptions, is contained in Table I, of the Appendix.
[2]Averages are for crop years 1890-91 to 1897-98, 1898-99 to 1904-05, 1905-06 to 1912-13, etc.
[3]Prices for 1890, 1891, 1892 missing.

Similar averages for certain selected economic series are given below.

TABLE 5
MEASURES OF MONTHLY VARIABILITY OF SIX ECONOMIC SERIES, 1890-1925
Averages, by Periods

(1)	(2) 1890–1897	(3) 1898–1905	(4) 1906–1913	(5) 1914–1921	(6) 1922–1925	(7) 1890–1925 inclusive	(8) 1890–1925 excluding 1914–1921
Yield on fifteen railroad bonds	1.4	1.3	1.4	2.5	1.3	1.6	1.4
Index of general business conditions (A. T. & T.)	5.3	2.7	2.8	4.3	4.8	3.9	3.8
Index of industrial stock prices (Dow-Jones)[1]	7.4	6.7	5.6	7.3	6.2	6.7	6.5
Pig iron production	14.1	7.6	9.0	10.9	12.8	10.6	10.6
Discount rate on 60–90 day commercial paper	13.7	11.6	10.6	8.8	7.6	10.8	11.3
Interest rate on call loans	31.6	36.6	33.0	18.9	12.0	28.0	30.6

[1]This is the Dow-Jones index for the period since 1897. For the years 1890-1896 the index computed by the Reports Department of the Federal Reserve Bank of New York, which carried back the Dow-Jones index by months to 1872, has been used. A full description of the measure will be found in *Interest Rates and Stock Speculation*, by Owens and Hardy (N. Y. Macmillan, 1925, Institute of Economics Series) pp. 139-144.

Measures of variability similar to those given above have been computed from the monthly values of a weighted index of railroad stock prices constructed by Frederick R. Macaulay. (This index, with an account of its construction, will appear in an early publication of the National Bureau of Economic Research.) The measure of monthly variability during the period 1890-1925 has a value of 4.3; for the same period, excluding 1914-1921, the value is 4.5. These are appreciably lower than the corresponding measures for industrial stocks.

In considering the significance of these figures it should be recalled that each of the eight-year averages rests, ultimately, upon 96 monthly price quotations, while the average for the four years, 1922-1925, rests upon 48 monthly quotations.

It is clear from Table 4 that individual commodities differ materially in the matter of price variability and, also, that the variability of specific commodities has changed from period to period. Thus the index for petroleum, which had stood at 9.0 and 9.4 during the first two periods, declined to 2.9 during the third period. As opposed to this, the index for rubber increased from 3.9 to 10.9 between the second and the third periods.

Since the pre-war years were divided into three eight-year periods, the relations between the averages for the first and third periods may be compared, in determining whether the tendency between 1890 and 1913 was in the direction of greater or less variability in the prices of individual commodities. Of the total number of commodities for which measures of monthly variability over the entire period have been computed (206), the prices of 78 were marked by increasing variability during the years from 1890 to 1913, 9 showed no change in the matter of price variability, and the prices of 119 became less variable. The general tendency was in the direction of declining variability.

These measures of variability by periods may be used to answer another question of some current interest. The last average given relates to the four years, 1922-1925. Was the variability of individual commodity prices during these years greater or less than during the years immediately preceding the war-time disturbances? This question may be answered, for any commodity, by comparing the average for the four years, 1922-1925, with the average for the eight-year period, 1906-1913. Of the total number of commodities studied, the prices of approximately two-thirds were more variable during the years 1922-1925 than they were during the eight pre-war years. The influence of the war-time disturbances upon individual prices has persisted, apparently, and, in so far as the four years from 1922 to 1925 may be used as a criterion, has left us with more variable prices than we had during the years immediately preceding the war.

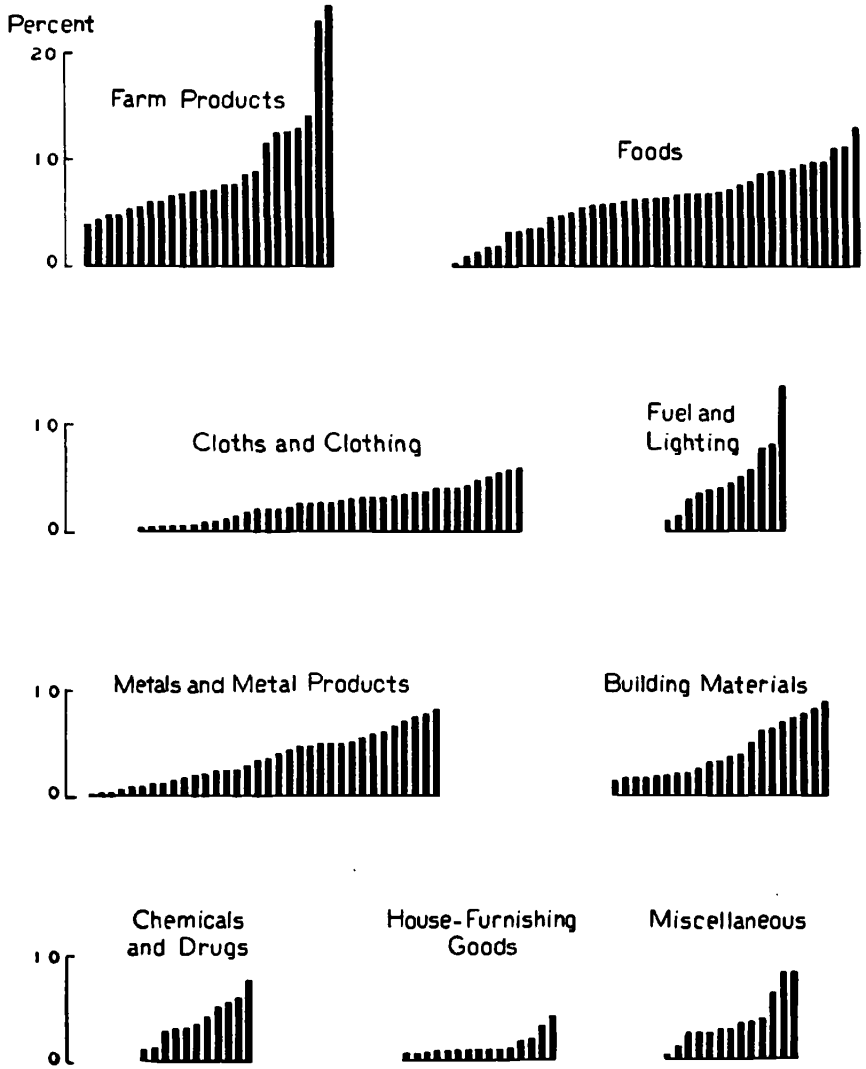
The general averages of monthly price variability, which are given in columns (8) and (9) of Appendix Table IV and of Table 4 of the text, may be used in comparing commodities in respect to their "proper fluctuations." To facilitate this comparison the commodities listed in these tables are arranged in order of magnitude of

FIGURE 3

VARIABILITY OF COMMODITY PRICES, AT WHOLESALE.

Ranking of Commodities by Groups according to the Monthly Variability of Prices.[1]

(Averages based upon monthly prices for the period 1890-1925, excluding 1914-1921.)



[1]Values of the variability measures for specific commodities are given in the Appendix, in order of magnitude, by groups, as plotted in this diagram. See Table VI for farm products and foods, and Table IV for all other groups.

the averages for the period 1890-1925, excluding 1914-1921. In Table IV the arrangement is by commodity groups, the groups being those employed by the United States Bureau of Labor Statistics.[1] A second arrangement of farm products and foods is made in Table VI, where crop year measures are used in determining the ranking of individual commodities.

The final averages in Table 4 range from 2.2 for steel rails to 13.9 for coke. The measures in the general table extend from .02 for trowels to 24.4 for onions. The variation within each group is shown by Figure 3, in which the data of Table IV are graphically presented. (The sections of the chart relating to farm products and foods follow the ranking of Table VI.) The wide differences between the measures for different commodities give evidence of the diversity of forces which are responsible for fluctuations in the prices of economic goods.

In comparing the measures for different commodities given in the preceding and certain following tables the differences in the original price quotations should be borne in mind.[2] Some of the original prices are averages of quotations at several plants or in several markets.[3] This prior averaging would tend to lessen the price variability of these commodities, as compared with other commodities for which quoted prices relate to a single market or a single plant. Again, some monthly prices are averages of daily or weekly quotations, while others are those prevailing on the first or fifteenth of the month. It is stated by the Bureau of Labor Statistics, however, that prices prevailing on the first or fifteenth of the month are taken only for those commodities which are quite stable in price. This being so, the measures of variability are probably not materially affected by the methods of securing price quotations.[4]

[1]The groups are those employed by the Bureau of Labor Statistics prior to the recent revision of its index number of wholesale prices.

[2]See Appendix Table I for a full description of the various commodities and their price quotations.

[3]This is true, for recent years, of the quotations on matches (average of 3 varieties) and common lime (average of 15 plants).

[4]A minor difficulty in the measurement of variability arose from the form in which actual prices are published by the Bureau of Labor Statistics. These prices are given to three decimal places, a form which is retained whether the price falls in the neighborhood of thirty dollars per unit (as for steel billets) or seven mills per unit (as for sulphuric acid). Thus the 1925 average price of steel billets is given as $35.452 (per ton) while the price of sulphuric acid is given as $.007 (per pound). A change of 1-100th of one per cent would be recorded for the former, while a change of ten per cent might not be reflected in the published price of the latter. It has been possible to meet this difficulty, in part, by using the relative prices which the Bureau publishes (which are always given to the first decimal place), but these relatives do not meet the needs of those whose interest lies in the actual prices. These needs would be best served, it

Difficulties of the same sort arise when measures of variability for different periods are compared. A radical alteration in the method of securing monthly prices might destroy the homogeneity of a series, for the present purpose.[1] The only general change of this nature made by the Bureau of Labor Statistics was in substituting average monthly prices (based on daily or weekly quotations) for first-of-the-month quotations. This change was made within recent years in computing the monthly prices of some 74 commodities, most of which were agricultural products, foods, or textiles. It is impossible to determine the effect of this substitution upon the magnitude of the monthly fluctuations, but there is no reason to believe that it has been material. In spite of these changes in the methods of securing certain quotations, the price series of the Bureau of Labor Statistics have been accepted as homogeneous for the purposes of the present study.[2]

2. The Measurement of Year-to-Year Variability

The variation of prices within the year represents a composite of secular, seasonal, cyclical and accidental factors. The fluctuations of commodity prices from year to year are due to a somewhat different set of forces. The seasonal element is not present. The influence of such accidental factors as affect prices over short periods only is eliminated, in large part. Cyclical swings, year-to-year variations due to crop changes or other factors affecting supply or demand, and the influence of trend are all present in the fluctuations of annual average prices.

The measure of year-to-year variability employed in the present study is the mean deviation (from the mean) of link relatives of average annual prices. The materials for such a measure were readily available, and the labor of computation was not excessive.

would appear, if all price quotations were given to the same number of *significant* figures. It is understood that the Bureau of Labor Statistics is planning to follow a somewhat different practice in publishing certain of its price series, aiming to eliminate the difficulty mentioned above.

[1] Professor W. M. Persons was led to reject eight of the price series published by the Bureau of Labor Statistics because there was doubt as to their homogeneity. These were men's hose, brown sheetings, serge dress goods, worsted trouserings, white pine doors, bedroom sets, men's boots, and smoking tobacco. (See "A Commodity Price Index of Business Cycles," *Review of Economic Statistics*, Prel. Vol. 3.) The rejection was, of course, based upon the needs of a particular investigation.

[2] The only exceptions are two series of prices relating to pails and tubs. Each of these series was spliced in 1914 by the substitution of galvanized iron vessels for wooden articles. These spliced series were rejected, in computing the present measure, because of the organic difference in the materials employed. In certain of the later calculations these were treated as consistent series.

This practical reason was reënforced by theoretical considerations. In measuring price variability it seems desirable to take account of the actual changes which occur from year to year, for it is these changes which affect business dealings and economic relations. The chief alternative measure, based on deviations from a line of trend, involves the use of a somewhat arbitrary base point for each year's calculations, a base point which becomes quite artificial and meaningless unless the fit of the trend line is satisfactory. Even when the fit is good it is questionable whether a measure of the variability of a time series should be based upon deviations from a line of trend. Actual fluctuations, not departures from a hypothetical trend, are the significant manifestations of variability. In these computations, accordingly, price changes from year to year are employed, instead of deviations from lines of trend. The effect of trend is in part eliminated, however, since the deviations which affect the value of the measure of variability are departures from the mean value of the link relatives for the period covered. In the case of a series increasing at a constant rate of 2 per cent a year, each of the annual link relatives would have a value of 102, and the mean deviation would be zero. In effect, then, the mean deviation of link relatives measures the variability due to departure from a constant rate of increase or decrease. When the rate of change is not constant, however, the averaging of deviations from the mean of the link relatives is not equivalent to averaging deviations from a line of trend.

a. *Year-to-Year Variability of Wholesale Prices.* In the analysis of wholesale prices two measures of annual variability have been computed for each commodity, one restricted to the pre-war years, 1890-1913, the other based upon average annual prices for the period 1890-1924. In measuring the variability of certain agricultural products, measures have been secured for both crop year and calendar year variability. All the results are shown in Table VII. The commodities within each group are arranged in order, according to the magnitude of the measures of pre-war variability. The ranking is based upon crop year measures, where these have been computed, but in these cases the measures of calendar year variability are also given.

Figures relating to nineteen selected commodities are given in the following table, the commodities being arranged according to degree of variability during the period 1890-1913. For purposes of

comparison measures of year-to-year variability relating to certain other economic series have been included in this table.

TABLE 6

MEASURES OF YEAR-TO-YEAR VARIABILITY OF PRICES OF SELECTED COMMODITIES, AT WHOLESALE, AND OF SIX GENERAL ECONOMIC SERIES

(1) Ref. No.	(2) Commodity	(3) Measures of variability[1] 1890–1913	(4) Measures of variability[1] 1890–1924
441	Leather	5.0	7.8
233	Anthracite coal	5.4	5.5
236	Bituminous coal	7.2	12.3
280	Steel rails	7.8	9.7
64	Beef	8.0	8.8
13	Cattle	9.1	10.5
149	Sugar, raw	9.4	14.2
202	Cotton yarns	9.9	16.2
120	Flour, wheat	11.2 (9.2)	15.5 (12.3)
195	Print cloths	11.7	17.9
6	Wheat	12.8 (11.7)	16.8 (13.9)
293	Copper, ingot	13.3	15.2
259	Pig iron	13.5	19.3
276	Steel billets	15.6	21.3
451	Rubber	15.9	16.6
25	Cotton	16.2 (14.2)	20.4 (18.2)
247	Petroleum	19.4	20.8
239	Coke	21.2	36.3
51	Potatoes	53.6 (34.5)	54.4 (39.4)
	Yield on fifteen railroad bonds	2.9	3.7
	Index of general business conditions (A. T. & T.)	6.9	7.7
	Index of industrial stock prices (Dow-Jones)[2]	14.2	14.3
	Pig iron production	16.0	20.3
	Discount rate on 60–90 day commercial paper	21.1	21.4
	Interest rate on call loans	50.0	42.2

[1]Where but one measure is given for a single commodity, it relates to calendar year variability. Where two are given, the first is based upon crop year prices, the second (in parentheses) upon calendar year prices.

[2]The corresponding values for Macaulay's index of railroad stock prices are 10.5, for the period 1890-1913, and 9.6, for the period 1890-1924.

The measures of pre-war price variability in Table 6 range from 5.0 for leather to 53.6 for potatoes, a range considerably in excess of that found in comparing measures of monthly variability. In the general table the range extends from .2 for trowels to 53.6 for potatoes.

Although there are certain notable differences in the ranking of individual commodities in respect to monthly and annual variability, there is some relation between the arrangement of commodities in the general tables (IV and VI, and VII). We have comparable measures for 206 commodities. The coefficient of correlation between measures of monthly variability, averaged for the years

1890-1913, and measures of year-to-year variability computed from average annual prices over the same period, has a value of +.70. This value suggests that the elements responsible for differences between commodities in respect to monthly price variability are only in part identical with the factors to which individual differences in year-to-year variability are due.

b. *Year-to-Year Variability of Retail Prices.* The measures of variability given in the preceding table have all been computed from wholesale prices. No such comprehensive series of quotations is available for retail markets, but the Bureau of Labor Statistics has compiled average annual prices for a limited number of foods at retail for the period since 1890. Although annual prices for only thirteen articles are obtainable for the entire period since 1890, some interest attaches to measures of variability computed from these figures. Each annual retail price is secured, it should be noted, by averaging prices prevailing in different cities. The number of dealers and the number of cities covered have varied somewhat. For the last several years merchants in 51 cities have reported their prices. Such averages would, of course, tend to fluctuate less than would average annual prices drawn from a single market. For these reasons it is not proper to compare the measures of wholesale price variability given in Table 6 with the retail measures following. Comparison of the different commodities for which retail prices are given is legitimate, however.

TABLE 7

MEASURES OF YEAR-TO-YEAR VARIABILITY OF FOOD PRICES, AT RETAIL

(Based upon calendar year averages for the United States, as computed by the United States Bureau of Labor Statistics)

(1) Commodity	(2) Measures of variability 1890–1913	(3) Measures of variability 1890–1924
Milk	1.4	4.0
Hens	2.9	5.2
Round steak	3.0	4.5
Butter	3.6	6.3
Eggs	3.7	5.9
Ham	3.8	5.9
Pork chops	4.1	6.7
Corn meal	4.2	8.0
Sugar	4.3	10.5
Bacon	4.4	7.0
Flour	5.7	8.7
Lard	7.0	10.2
Potatoes	10.6	17.5

The range of values within which these measures fall is distinctly smaller than that for wholesale prices, but within this range there are important differences between individual commodities. These differences would doubtless be much more pronounced if the price quotations employed were drawn from single markets, as is done for most of the wholesale price quotations.

c. *Year-to-Year Variability of Farm Prices.* For a limited number of agricultural products the averages of farm prices[1] prevailing on December 1st of each year are available, for the period covered by this study. Each annual price for the United States is secured by averaging the farm prices prevailing in the several states on December 1st. The annual figures thus differ in important respects from the wholesale price averages employed in computint the figures given in Table 6 and from the retail price averages upog which Table 7 is based. The figures given below, relating to eighn important farm products, are therefore not directly comparable with the wholesale and retail measures. The different entries in Table 8 may, however, be compared with each other.

TABLE 8

MEASURES OF YEAR-TO-YEAR VARIABILITY OF FARM PRICES OF SELECTED AGRICULTURAL PRODUCTS

(Based upon averages, for the United States, of December 1st farm prices, as computed by the United States Department of Agriculture)

(1) Commodity	(2) Measures of variability 1890–1913	(3) 1890–1924
Rye	10.5	15.6
Hay	10.6	11.7
Wheat	12.5	16.2
Barley	13.7	18.4
Oats	17.4	18.3
Corn	19.5	22.3
Cotton	22.1	27.4
Potatoes	32.7	33.9

An interesting feature of this table, in comparison with that relating to prices in the wholesale markets, is found in the difference in the relative positions of the five grains. In the wholesale markets the ranking of the five grains, based upon year-to-year price variability (1890-1913), is wheat, rye, corn, barley and oats, wheat being least variable. The farm price of rye is least variable, with wheat

[1]Farm prices are the prices received by producers.

next in line. Barley is third (of the grains) in the farm price list and fourth in the wholesale price list, while oats are fourth in the farm price and fifth in the wholesale price list. The ranking of corn based on farm prices is fifth, as compared with a third place in the other list.

It was suggested above that the comparison of actual values in the farm price and in the wholesale price lists is not justified. The farm prices, being averages for the United States, would tend to be more stable than would wholesale price quotations in a single market.[1] On the other hand, the farm prices are December 1st prices, while the wholesale prices are averages for the year. We may come as close to perfect comparability as is possible with the available data by comparing farm prices prevailing on December 1st in a single state with December prices in a given wholesale market. This has been done in preparing the following table. For each of the six commodities listed, the year-to-year variability of December 1st farm prices in the chief (or a leading) producing state has been computed. This measure is compared with the year-to-year variability of average December wholesale prices in Chicago

TABLE 9

RELATIVE VARIABILITY OF PRICES OF SIX FARM PRODUCTS

COMPARISON OF MEASURES OF YEAR-TO-YEAR VARIABILITY OF DECEMBER FARM PRICES IN SPECIFIC STATES AND DECEMBER WHOLESALE PRICES IN CHICAGO*

(1)	(2)	(3)	(4)	(5)
	Measures of variability			
	1890–1913		1890–1924	
Commodity	Farm prices	Wholesale prices	Farm prices	Wholesale prices
Wheat	15.8	13.6	18.1	17.9
Rye	18.6	17.2	25.4	22.8
Barley	20.9	20.7	25.3	24.1
Oats	26.1	22.5	25.8	22.6
Corn	29.7	23.0	30.7	26.4
Potatoes	48.9	47.5	53.7	47.3

*The wholesale prices to which the above measures relate are cash Chicago prices. The farm prices are those prevailing on December 1st in the following states:

Wheat:	Kansas
Rye:	North Dakota
Oats:	Iowa
Barley:	North Dakota
Corn:	Iowa
Potatoes:	Minnesota

[1]The stabilizing effect of the averaging process is apparent from a comparison of the following figures, measuring the year-to-year variability of December 1st farm prices of

It is clear that the year-to-year variability of December farm prices in the chief producing states is greater than the year-to-year variability of December wholesale prices in Chicago. The ranking of the grains in the matter of price variability is the same for both farm and wholesale prices, when the study is restricted to pre-war prices. The inclusion of prices for the years 1914-1924 changes the ranking slightly.

§Week-to-Week Variability of Prices

As an illustration of another type of variability, results secured by C. E. Artman in studying wholesale prices of fruits and vegetables in the New York market may be cited. His measures relate to week-to-week variability within a single market for a single season, a type of variability quite distinct from the monthly and year-to-year variability which have been discussed above. As a measure of variability Artman employed "the average week-to-week change in price, either up or down, expressed as a percentage of the season's mean wholesale price for the given commodity." The following measures of variability were secured:

Northern potatoes	3.2	Yellow onions	13.5
Boxed apples	4.6	Western lettuce	19.6
Sweet potatoes	5.4	Cantaloupes	22.8
Barreled apples	8.0	Peaches	24.1
California oranges	9.2	Southern cabbage	25.9
Southern potatoes	11.8	Eastern lettuce	26.4
Northern cabbage	12.8		

(From: C. E. Artman, *Food Costs and City Consumers*, Columbia University Studies, No. 280, p. 90.)

Artman points out that this grouping of commodities according to week-to-week variability in wholesale prices agrees in general with their ranking in regard to perishability.

oats in 10 states, and in the United States. The measures are computed from prices for the years 1890-1913.

Region	Measure of year-to-year variability of farm prices of oats, 1890-1913 (based on December 1st prices)
California	10.9
Ohio	17.0
Minnesota	18.5
Wisconsin	19.5
Texas	19.7
Indiana	20.3
Illinois	21.5
South Dakota	22.4
Nebraska	22.5
Iowa	28.7
United States	17.4

Most of these articles are not duplicated in the tables above, nor in the general tables in the Appendix. The difference in the position of potatoes is perhaps the most notable feature. In week-to-week variability during the marketing season, which is apparently a function of perishability, potatoes rank low in comparison with other fruits and vegetables, but their monthly and year-to-year price variability is high.

3. Measurement of the Frequency of Monthly Price Changes

It is desirable, in measuring the variability of commodity prices, to take account of the frequency of change as well as the degree of change in prices. The smallest time unit covered by the available data is the month, so that we are restricted to a study of the frequency of change in monthly prices. A smaller time-interval would be desirable in a comprehensive investigation of frequency of price change.

The question of the comparability of the different price series employed must be carefully considered in such a study. We must distinguish all price series which are averages of a number of constituent series, for such averages could not legitimately be compared, in respect to frequency of change, with price series taken from a single market or the files of a single manufacturer.[1] A second difficulty arises in comparing commodities the prices of which are quoted as of a given day of the month (first or fifteenth) with commodities for which the monthly prices are secured by averaging daily or weekly quotations. Only for those commodities which remain constant in price over an extended period is it the practice of the Bureau of Labor Statistics to use a quotation relating to a single day of the month. In general, for such commodities, the average price for the month would presumably be the same as the price on the first or fifteenth of the month. It has been considered justifiable, therefore, to compare commodities for which monthly prices are secured in these various ways, though the data are not in the most satisfactory shape for the purpose. In utilizing and inter-

[1]In the list of commodities for which measures of frequency of price change have been computed in the present study there are only two for which price quotations represent averages (i. e., averages of prices at different plants or in different markets) during any part of the period covered. These are matches (commodity no. 244) and lime (commodity no. 338). Since 1913 the published prices on the first of these have represented averages of prices on three grades, while the published prices for lime have been secured by averaging prices at fifteen plants. The effect on the frequency of change in the prices of matches is not apparent in the figures, but the alteration in the lime quotation is probably the main factor in the great apparent increase in the frequency of price change in post-war years. For the period 1906 to 1913 the measure of frequency of price change for lime had a value of .10; for the years 1922 to 1925 the value was .98.

preting the results, the sources of the individual price quotations (as listed in Table I) must be borne in mind. In some cases differences in frequency of change may be attributed to the source of the quotation (e. g. when plant prices for one commodity are compared with prices for another on a commodity exchange), but differences of this sort are not without significance.

The measure employed in studying the frequency of price change for a given commodity is a simple one. It is the ratio of the number of price changes to the total number of months, less one, for which prices are available. Thus if the price of a commodity were quoted for 240 months, and if in 239 of these months price changes were recorded, the index of frequency of price change would be given by the ratio 239/239, or 1.00. The denominator is taken as the total number of cases less one, since the first month of the series cannot be compared with the month preceding. The maximum value of the ratio is, therefore, unity. A value of zero means, of course, that there have been no price changes during the period covered.[1]

As in the case of the index of monthly variability, the measure of frequency of price change has been computed by periods. These measures are shown for all commodities in Appendix Table VIII, and for nineteen selected articles in Table 10, below. The changes from period to period, which were noted in the case of the other index, are also found in these tables. The measure of frequency of change for coke increased from .38 to .92 between the first and third periods; that for petroleum declined from .97 to .24. When the measures of frequency of price change for all the commodities studied (206) are examined, by periods, there is found a rough balance between the number which showed an increase in the frequency of change and those which showed a decrease, during the period 1890-1913. The frequency of price change declined for 95 commodities, increased for 92 and remained constant for 19.

Comparing the figures for the four years, 1922-25, with those for the last pre-war period, 1906-13, we find the same tendency toward greater variability in the post-war years which was observed in the study of the measures of monthly variability. Of the 206 articles listed in Table VIII, 137 showed an increase in the fre-

[1]Variations in the number of significant figures in the various price quotations of the Bureau of Labor Statistics lessens somewhat the comparability of the results for different commodities. The effect of these variations upon the measures of frequency of price change is probably not great, however.

TABLE 10

MEASURES OF FREQUENCY OF MONTHLY CHANGES IN PRICES OF SELECTED COMMODITIES, AT WHOLESALE, BY PERIODS, 1890-1925

(1) Ref. No.	(2) Commodity	(3) 1890–1897	(4) 1898–1905	(5) 1906–1913	(6) 1914–1921	(7) 1922–1925	(8) 1890–1925 inclusive	(9) 1890–1925 excluding 1914–1921
280	Steel rails	.23	.18	.00	.14	.04	.13	.12
236	Bituminous coal	.71	.37	.25	.27	.37	.38	.41
441	Leather	.37	.56	.43	.44	.54	.46	.46
247	Petroleum	.97	.41	.24	.46	.73	.54	.56
239	Coke	.38	.60	.92	.72	.98	.69	.68
202	Cotton yarns	.66	.72	.71	.91	.98	.78	.74
259	Pig iron	.61	.84	.79	.68	.92	.75	.77
149	Sugar, raw	.69	.79	.74	.70	1.00	.76	.78
276	Steel billets	.99	.82	.68	.69	.69	.79	.81
195	Print cloths	.93	.87	.81	.93	.94	.89	.88
293	Copper, ingot	.90	.82	.94	.84	.94	.88	.89
233	Anthracite coal	.95	.93	.89	.95	.98	.93	.93
451	Rubber	.93	.95	.95	.87	.98	.93	.95
64	Beef	.96	.98	.93	.99	.98	.96	.96
25	Cotton	.98	.98	1.00	1.00	1.00	.99	.99
13	Cattle	.98	1.00	1.00	.99	1.00	.99	.99
120	Flour, wheat	1.00	.98	1.00	1.00	1.00	.99	.99
51	Potatoes	1.00	99	1.00	.99	1.00	.99	1.00
6	Wheat	1.00	1.00	1.00	.91	1.00	.98	1.00

quency of price change in the years following the war, 43 showed a decline, while for 26 the pre-war and post-war measures were equal.

In addition to the measures of frequency of price change by periods, two general measures are given in these tables. One is based upon monthly prices over the entire period from 1890 to 1925, the other upon the same quotations, excluding the disturbed years from 1914 to 1921. The latter is probably the more representative measure of frequency of price change. The commodities listed in Tables 10 and VIII are ranked on the basis of this measure.

The range in Table 10 extends from .12, for steel rails, to 1.00, for potatoes and wheat. These figures mean that a change in the price of steel rails was recorded in 12 per cent of the months for which prices were available, while potatoes and wheat changed in price every month during the period covered. The lowest value in the general table (VIII) is .01 (actually .006) for crosscut saws and trowels. A change in price took place for these articles in less than one month out of every hundred,

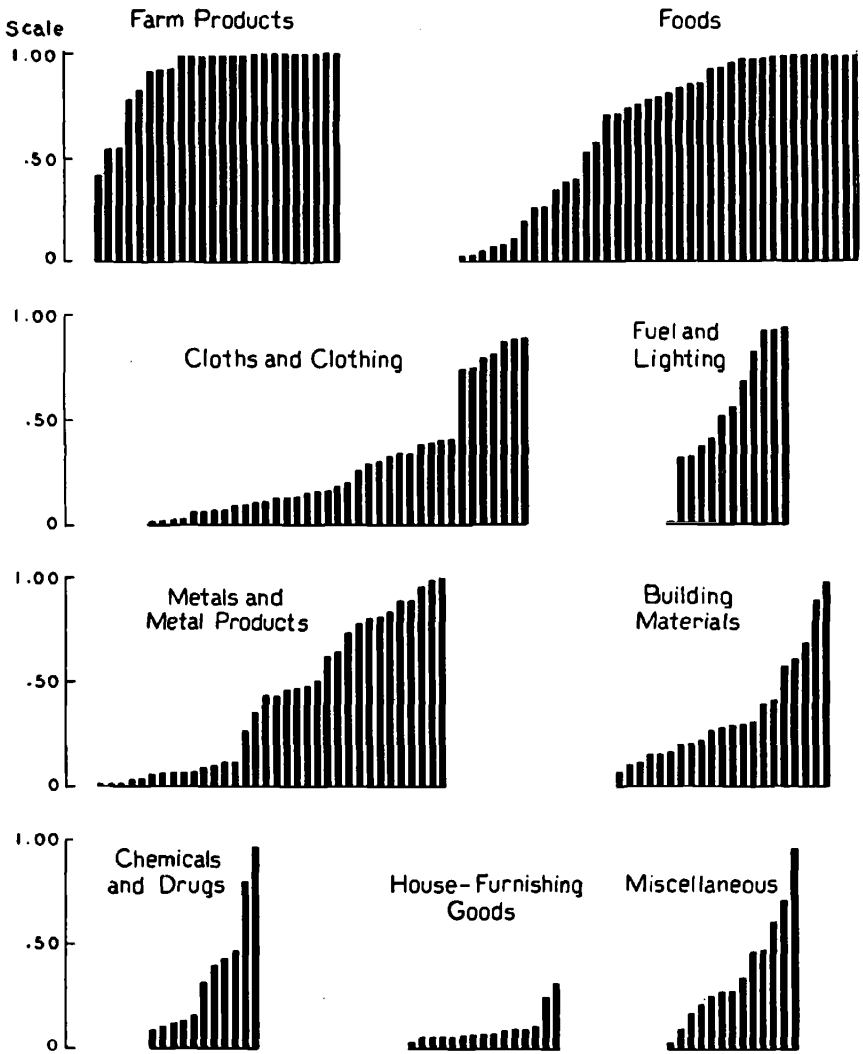
In Figure 4 the indexes of frequency of price change for 206 commodities are plotted, by groups.

FIGURE 4

FREQUENCY OF CHANGE IN COMMODITY PRICES, AT WHOLESALE.

Ranking of Commodities by Groups according to the Frequency of Month-to-Month Price Changes.[1]

(Measures based upon monthly prices for the period 1890-1925, excluding 1914-1921.)



[1]Values of the measures of frequency of change for specific commodities are given in Table VIII, in order of magnitude, by groups, as plotted in this diagram.

Three different measures of price variability have been given in the preceding pages. Some degree of relationship between these different indexes is to be expected, since they measure, in part, the effects of the same forces. The coefficients of correlation measuring these relations are given below:

Series correlated	No. of observations	Coefficient of correlation[1]
Measure of monthly variability Measure of year-to-year variability	206	+.70
Measure of year-to-year variability Measure of frequency of monthly price change	206	+.58
Measure of monthly variability Measure of frequency of monthly price change	206	+.73

Although these coefficients indicate that the different measures of price variability are not independent, they show, as well, that there are important differences between them. The factors responsible for these three types of price variation are in part common, but each measure reflects, in addition, the influence of specific factors which affect one type of price movement alone.[2]

§Other Measures of Price Variability

It would be possible to develop numerous other measures of price variability, but the main purposes of the present investigation are served by the three described above. The effects of seasonal and other causes of short-term variability are adequately measured by the first of these; the effects of major cyclical swings and of crop and other factors which cause commodity prices to vary from year to year are measured by the second. The third gives some indication of the degree of control exercised in the fixing of the various commodity prices, and throws some light on the nature of the price competition prevailing in different lines.

[1]In a few of the cases tested in this study slightly higher measures of correlation would be secured if non-linear, rather than linear relationships, were assumed. Such cases are few, however, and it does not appear from inspection that the differences would be pronounced. It has been considered advisable, therefore, to assume linear relationships and to employ the coefficient of correlation throughout.

[2]One important group of prices has been omitted in the preceding analysis. These are contract prices, which are of considerable importance in certain basic industries. It is certain that the behavior of contract prices in the matter of variability, and in other respects, differs materially from the behavior of the market and farm prices to which the above discussion relates. It is hoped that a comprehensive study of contract prices may be made at a later time.

The problem of measuring price variability has been faced in certain other studies dealing with specific commodities. A brief account of the measures employed is pertinent.

In various investigations of the effect of speculation upon price fluctuations, use has been made of the monthly or annual range (i. e. the difference between the highest and the lowest prices). In some cases this range has been expressed as a percentage of the average. Whether in absolute or relative form, however, this is a measure of limited significance. The difference between the results secured by the employment of the range and those obtained by other methods is well illustrated by figures relating to wheat, barley and oats. James E. Boyle (*Speculation and the Chicago Board of Trade*, N. Y. Macmillan, 1920, pp. 122-3) contending that "Speculation on the organized exchanges lessens (price) fluctuations," presents as proof measures of the price variability of these three grains, computed from prices for the years 1899-1916. These measures are the "extreme price ranges for each year" expressed, apparently, as percentages of the average price for each year. The fluctuations are smallest in wheat prices and greatest in the price of barley, with oats falling between. From which Dr. Boyle concludes that future trading tends to stabilize prices, since wheat and oats are traded in on the organized exchanges while barley is not. The difference between oats and barley is emphasized by Dr. Boyle. Pointing out that oats and barley are similar in their production and use, he concludes that the difference in their price variability may be attributed to the fact that one is dealt in on the exchanges, while the other is not.

From the tables presented above we have the following figures relating to these three grains:

TABLE 11

MEASURES OF PRICE VARIABILITY FOR WHEAT, BARLEY AND OATS

(1) Grain	(2) Monthly variability 1890–1925	(3)	(4)	(5)	(6) Year-to-year variability 1890–1924	(7)	(8)	(9)
	Calendar year		Crop year		Calendar year		Crop year	
	incl. 1915–22	excl. 1915–22	incl. 1914–15 to 1921–22	excl. 1914–15 to 1921–22	1890–1913	1890–1924	1890–91 to 1913–14	1890–91 to 1924–25
Wheat	7.7	7.0	6.6	5.5	11.7	13.9	12.8	16.8
Barley	9.9	9.0	7.1	6.2	16.4	16.3	17.8	20.6
Oats	10.8	11.0	7.6	6.8	16.1	16.6	19.8	20.3

In the eight different comparisons we find barley more variable than oats only twice. In these two cases the differences are very slight. In the six other cases the variability of barley prices is less than that of the prices of oats. Wheat, in all cases, is less variable in price than the two other grains.

The differences between the two sets of results for barley and oats may be in part due to differences in the periods covered. (The prices employed in the present study cover a longer period of years than those quoted by Dr. Boyle.) More important, however, is the fact that Dr. Boyle's figures relate to the annual range of price fluctuations, while the figures tabulated above measure average monthly movements and average year-to-year changes. In interpreting the results, a clear distinction should be made between the different types of price variability which are being measured. If we have in mind either average monthly variations or year-to-year changes, no such conclusion as that drawn by Dr. Boyle appears to be justified.

Of more general significance than the crude range employed by Dr. Boyle is the standard deviation, which was used in an early report on future dealings in raw produce (chiefly wheat) made in 1900 by a committee of Section F (Economic Science and Statistics) of the British Association, and later by Chapman and Knoop in a paper on "Dealings in Futures on the Cotton Market" (*Journal of the Royal Statistical Society*, Vol. 69, 1906). Chapman and Knoop used, in computing this measure, the deviations of weekly prices from crop-year averages. In both these studies the standard deviation was supplemented by a measure of the mean weekly (or daily) movement. Similar measures have been employed in various other studies dealing with speculation and commodity prices.

Abraham Berglund, studying fluctuations in steel prices ("The United States Steel Corporation and Price Stabilization," *Quarterly Journal of Economics*, November, 1923) employed measures of variability based upon extreme fluctuations. Berglund considered these more significant for his purpose than any measure of average deviation. Accordingly, he divided the interval 1898-1922 into three periods (1898-1901, 1902-1914, 1915-1922), determined the average price of finished steel in each of these periods, and measured the extreme deviations of monthly and annual averages, in each period, from these average prices. Use was made also of figures showing the extreme monthly deviations from annual averages. Throughout the emphasis was upon the widest fluctuations, not upon average deviations. While such a method may be desirable for certain purposes, no measure based upon isolated fluctuations can be considered generally satisfactory.

A more elaborate method, developed by G. P. Watkins (see "The Measurement of Concomitance of Variation," *Journal of the American Statistical Association*, March, 1923, June, 1923) has been employed by the Federal Trade Commission in studying the variability of grain prices. (The results appear in *The Grain Trade*; Vol. VI, *Prices of Grain and Grain Futures*.) The index of variability employed is derived from the antilogarithm of the average of the logarithmic differences between successive items in the original series, a correction for trend being applied before the logarithmic differences are averaged. In computing logarithmic differences, the smaller number is always subtracted from the larger, regardless of chronological order, hence we are dealing with the ratio of the larger to the smaller number in each pair. Careful testing has not

shown that this index possesses any advantage over the simpler measure of variability here employed in measuring year-to-year movements. Allowing for the slight distortion of the logarithmic index due to the fact that the ratios which are averaged are always those of the larger of each pair to the smaller, the results secured from the two methods are very nearly the same, except when the variability is great. In such cases the preponderant influence of the large ratios (the smaller being the base in every instance) makes the logarithmic index considerably greater than that based on link relatives. There is, in both methods, some correction for trend. One employing the logarithmic method corrects each of the logarithmic differences by a proportionate part of the difference between the logarithms of the first and last entries in the series. The link relative method involves the measurement of deviations from the mean of all the link relatives. When the series increases at a constant rate, year by year, the two corrections for trend will agree, but they will give different results under other conditions.

The ranking of the grains according to year-to-year price variability, as given by the Federal Trade Commission (*The Grain Trade* Vol. VI. *Prices of Grain and Grain Futures*, pp. 27-8), differs but slightly from that secured in the present study. The corresponding measures are given below. They are based upon cash prices at Chicago, averaged by crop years. Since the Federal Trade Commission's averages do not include the years of greatest disturbance following upon the war, the measures derived in the present study from pre-war prices are given for comparison.

TABLE 12

MEASURES OF YEAR-TO-YEAR VARIABILITY OF THE PRICES OF FIVE GRAINS

(1) Grain	(2) Present inquiry 1890-91 to 1913-14	(3) Federal Trade Commission 1886-87 to 1915-16
Wheat	12.8	14.8
Rye	14.6	17.5
Corn	14.8	16.7
Barley	17.8	20.1 (1893-1916)
Oats	19.8	22.7

The absolute differences between the two sets of measures are not significant, since they are computed by different methods. The two rankings differ only with respect to the position of rye and corn, the former being second in the ranking based upon the present study and third in the Federal Trade Commission's ranking. The two studies agree in placing oats as the most variable of the grains in year-to-year price movements. In this their conclusions differ from those of Professor Boyle, based upon the range of annual fluctuations during the years 1899-1916.

More pronounced are the differences in ranking based upon the

variability of monthly prices. The Federal Trade Commission has computed measures of monthly price variability (using the method described above) for the five grains, employing cash Chicago prices for the period from 1909 to 1914. These may be compared with measures based upon monthly cash prices at Chicago during crop years from 1890 to 1925, excluding 1914 to 1921.

TABLE 13

MEASURES OF MONTHLY VARIABILITY OF THE PRICES OF FIVE GRAINS

(1) Grain	(2) Present inquiry 1890–91 to 1925-26 (excluding 1914–15 to 1921-22)	(3) Federal Trade Commission July, 1909, to June, 1914
Wheat	5.5	3.5
Barley	6.2	5.3
Rye	6.5	3.7
Oats	6.8	5.4
Corn	8.8	5.3

The methods of measuring variability differ more radically in this case than in the case of year-to-year movements. This fact, together with the difference in the periods covered, doubtless accounts for the differences in the results.

In *An Academic Study of Some Money Market and Other Statistics* (London, P. S. King, 1926) E. G. Peake gives measures of year-to-year variability in the prices of 43 articles which enter into Sauerbeck's index of wholesale prices in England. These are computed from fixed base relatives, the base being the average price, during the years 1867-77, of each commodity. The average of the year-to-year changes in these relatives furnishes a first measure of variability. Such an average has been computed for the periods 1850-1879 and 1880-1909. A second measure of variability, in relative form, has been secured by expressing each of these averages as a percentage of the average value of the fixed base relatives for the commodity in question over the period covered. The chief difference between Peake's measure of variability and the year-to-year measure employed in the present study lies in the nature of the original price relatives employed. Peake averages the difference between annual values of fixed base relatives; in the present inquiry annual link relatives have been employed in measuring year-to-year changes. The former method would give the same weight to a change in the relative price from 150 to 170 as to a change from 40 to 60. On the link basis the former represents an increase from 100 to 113.3; the latter represents an increase from 100 to 150. If a commodity undergoes a considerable change in price during the period for which year-to-year changes are to be averaged, the measure of variability computed by Peake's method would be somewhat distorted, giving undue weight to the changes occurring at the higher price level.